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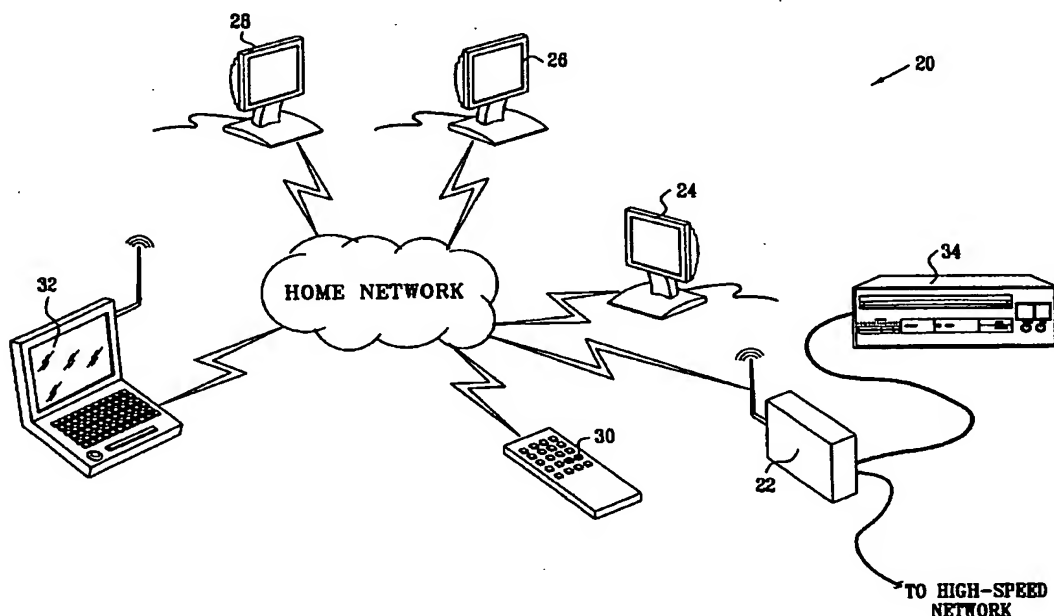
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(54) Title: **WIRELESS VIDEO DISTRIBUTION**



(57) Abstract: A data distribution device (22) includes a high-speed radio-frequency (RF) wireless transmitter (50), operative to transmit digital data to one or more peripheral devices (24, 26) at a high data rate over a wireless local area network (20) in a broad band at a first frequency, and a low-speed RF wireless receiver (58), operative to receive signals returned by the one or more peripheral devices over the network in a narrow band at a second frequency.

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WIRELESS VIDEO DISTRIBUTION**FIELD OF THE INVENTION**

The present invention relates generally to local area networks, and specifically to high-speed wireless
5 local area networks.

BACKGROUND OF THE INVENTION

Data networking is increasingly moving out of the professional environment and into the home. A home local area network (LAN) can be connected to a high-speed data
10 link, such as a Digital Subscriber Line (DSL) or satellite connection, in order to give residents access to high-bandwidth services, such as Internet browsing and video on demand. The network should be configured so that a number of computing devices and peripherals, such
15 as video monitors, can share the data link and other resources simultaneously.

Installing a network in a home can be costly, particularly when an existing home, without a built-in network infrastructure, must be wired. The wires
20 themselves are unsightly and inconvenient, limiting the residents' ability to place computing devices and peripherals where they would like them and to move them around after the network has been installed. For this reason, there has been growing interest in wireless home
25 networking, particularly using radio-frequency (RF) communications among networked devices.

For example, the IEEE 802.11 standard, which is incorporated herein by reference, defines a number of different modulation schemes that can be used for in-home
30 RF wireless networking. These schemes use RF bands at 2.4 and 5.5 GHz that have been set aside by the Federal Communications Commission (FCC) for unlicensed use. The 2.4 GHz band can provide data rates up to 11 Mbps, but

this level is not adequate for multi-channel high-quality video, particularly when high-frequency flat-panel displays are used. On the other hand, the 5.5 GHz band can provide up to 54 Mbps, using Orthogonal Frequency
5 Division Modulation (OFDM). RF transmitters and receivers for this high frequency and high data rate are costly, however, and the cost can become prohibitive when multiple computing devices and peripherals must be equipped for wireless networking at this level.

10

SUMMARY OF THE INVENTION

It is an object of the present invention to provide improved apparatus and methods for wireless networking.

It is a further object of some aspects of the present invention to provide a wireless local area
15 network, particularly for residential environments, that enables distribution of multi-channel digital video data at high rates without excessive cost.

In preferred embodiments of the present invention, a wireless local area network comprises a high-speed data
20 distribution device, which distributes digital data at a high data rate to one or more peripheral devices at a first radio frequency. The peripheral devices return acknowledgment and other control signals to the distribution device at a second, typically lower radio
25 frequency, with a substantially lower data rate. Typically, the digital data distributed by the distribution device comprise video data, preferably multiple channels of video data distributed respectively to a plurality of video displays in a home or other
30 facility. Most preferably, the distribution device transmits the digital data in the 5.5 GHz band, while the acknowledgment and control signals are returned in the 2.4 GHz band, as specified by the IEEE 802.11 standard. Alternatively or additionally, other bands and standards

may be used, and the distribution device may distribute other types of high-speed data, as well.

The use of different bands and different data rates for data distribution and for return of control signals
5 mitigates the overall cost of the network, without reducing the number of channels or the quality of the signals that are distributed. Only the distribution device need include a costly, high-frequency transmitter, while the peripheral devices can make do with low-
10 frequency, low-rate transmitters, which are far less expensive.

In some preferred embodiments of the present invention, the network includes multiple distribution devices. For example, in one preferred embodiment, one
15 distribution device serves as an access point to an external wire-line network, and a personal computer serves as another distribution device. Both (or all) of the distribution devices transmit high-rate data to the peripheral devices and receive low-rate return data
20 therefrom. The distribution devices also exchange data with one another at either the high rate or the low rate, depending on application requirements. The network may comprise substantially any combination of distribution devices and peripheral devices. The configuration of
25 communication links in the network may be varied freely, and there is no need for a central controller to manage the communications among the devices.

In further preferred embodiments of the present invention, the network also includes one or more remote
30 control devices, which transmit and receive data at the low data rate. These devices allow a mobile user to control elements of the network, for example, to select a video program to view on one of the displays, by communicating at the low rate either with one of the

peripheral devices or with one of the distribution devices.

There is therefore provided, in accordance with a preferred embodiment of the present invention, a data
5 distribution device, including:

a high-speed radio-frequency (RF) wireless transmitter, operative to transmit digital data to one or more peripheral devices at a high data rate over a wireless local area network in a broad band at a first
10 frequency; and

a low-speed RF wireless receiver, operative to receive signals returned by the one or more peripheral devices over the network in a narrow band at a second frequency.

15 Preferably, the digital data include video data, and wherein the one or more peripheral devices include one or more displays, which receive the transmitted video data and display video images responsive thereto. Further preferably, the one or more displays include a plurality
20 of displays, and the transmitter is adapted to transmit a different respective channel of the video data to each of the displays. Most preferably, the signals returned by the one or more peripheral devices indicate a choice of the respective channel made by a user of one of the
25 displays. In a preferred embodiment, the device is coupled to receive the digital data at the high data rate from a public communications network.

In a preferred embodiment, the first frequency is between 5 and 6 GHz, and the second frequency is between
30 2 and 3 GHz. Preferably, the transmitter and receiver are respectively operative to transmit the data and to receive the signals substantially in accordance with IEEE standard 802.11.

There is also provided, in accordance with a preferred embodiment of the present invention, home networking apparatus, including:

5 an access point, operative to transmit digital data over the air at a high data rate in a broad band at a first frequency; and

10 one or more peripheral devices, operative to receive the digital data transmitted by the access point and to return signals to the access point at a low data rate in a narrow band at a second frequency.

Preferably, the apparatus includes a personal computer, coupled to communicate over the air with the access point in the broad band. Additionally or
15 alternatively, the apparatus includes a remote control device, adapted to communicate over the air in the narrow band with at least one of the access point and the peripheral devices. Preferably, the remote control
20 device is operative to communicate over the air with one of the peripheral devices, which is further operative to return the signals to the access point responsive to communication with the remote control device.

There is additionally provided, in accordance with a preferred embodiment of the present invention, a method for data distribution, including:

25 transmitting digital data over the air to one or more peripheral devices at a high data rate over a wireless local area network in a broad band at a first frequency; and

30 receiving signals returned by the one or more peripheral devices over the network in a narrow band at a second frequency.

The present invention will be more fully understood from the following detailed description of the preferred

embodiments thereof, taken together with the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic, pictorial illustration of a wireless home network, in accordance with a preferred embodiment of the present invention;

Fig. 2A is a block diagram that schematically illustrates transmission of data in the network of Fig. 1, in accordance with a preferred embodiment of the present invention;

Fig. 2B is a block diagram that schematically illustrates details of certain elements of Fig. 2A, in accordance with a preferred embodiment of the present invention;

Fig. 3 is diagram that schematically illustrates data and message flow among the elements of Fig. 2A, in accordance with a preferred embodiment of the present invention; and

Fig. 4 is a block diagram that schematically illustrates transmission of data in the network of Fig. 1, in accordance with another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 is a schematic, pictorial illustration of a wireless home network 20, in accordance with a preferred embodiment of the present invention. Elements of the network communicate with one another using radio frequency (RF) signals, preferably in the 2.4 GHz and 5.5. GHz bands, as specified by the IEEE 802.11 standard. Network 20 makes use of these two different bands in a novel way.

An access point 22 couples network 20 to one or more sources of high-speed data. Preferably, the access point is connected to a high-speed public network, typically a

wire-line network, such as a public switched telephone network (PSTN) or a broadband cable network. Alternatively or additionally, the access point is linked to a satellite or other wireless network external to the home. For this purpose, the access point preferably comprises or is connected to a suitable modem, cable set-top box or other transceiver, as is known in the art. The public network provides multi-channel programming, such as video on demand, which is distributed by the access point to other elements of network 20. Additionally or alternatively, the access point is connected to a local media source 34, such as a DVD drive.

Access point 22 distributes video data (preferably including audio, as well) over network 20 to a plurality of video displays 24, 26, 28. The displays preferably comprise high-resolution flat panel displays, but may alternatively comprise cathode ray tube (CRT) television monitors, video projectors, or substantially any type of display device known in the art that is equipped with a suitable wireless receiver and transmitter. Alternatively or additionally, other devices that need to receive high-speed data, but transmit only at a lower rate, may be configured in network 20 in like manner to the video displays. Preferably, network 20 has sufficient data distribution bandwidth so that a different video channel may be selected and displayed on each of the displays. Channel selections, as well as other display and program parameters, are most preferably controlled using one or more remote control devices 30, also using RF signals.

Optionally, one or more personal computers 32 are similarly coupled to communicate over network 20 with either access point 22 or monitors 24, 26, 28, or with

both. Communication with the access point gives computer 32 access to the above-mentioned high-speed networks and other media, at a high data rate. Communication with the displays enables computer 32 to use one or more of the
5 displays as high-resolution monitors. Alternatively, the functions of access point 22 and computer 32 are combined in a single module.

Reference is now made to Figs. 2A and 2B, which are block diagrams that schematically illustrate
10 communications carried out among elements of network 20, in accordance with a preferred embodiment of the present invention. Fig. 2A provides an overview of RF communication paths 44, 46 and 48 within the network, while Fig. 2B shows details of access point 22, monitor
15 24 and remote control 40. Access point 22 comprises a high-speed RF transmitter 50, which preferably operates at 5.5 GHz, in accordance with the IEEE 802.11 standard, to transmit multiple video channels using OFDM modulation over a wide-band, high-speed data path 44. Transmitter
20 50 is thus capable of serving multiple displays 24, 26, etc. (although for simplicity, only display 24 is shown in Fig. 2B). Most preferably, the video data are transmitted in a synchronous mode, for efficient bandwidth utilization, and an inter-packet coding scheme
25 is used to reduce the probability of losing a packet of data. Access point 22 is also coupled by wired connection paths 48 to media source 34 and/or to one or more high-speed public networks, as mentioned above.

Display 24 comprises a high-speed RF receiver 52,
30 which receives and demodulates the data transmitted by transmitter 50 over path 44, so that the desired video program can be displayed on a monitor screen 62. Preferably, the transmitted data are compressed, using MPEG-standard compression, for example, as is known in

the art, and display 24 comprises suitable real-time decompression circuitry. Display 24 also comprises a low-speed transmitter/receiver 54, or alternatively, only a transmitter, which preferably operates over a low-speed path 46 at 2.4 GHz, similarly in accordance with the above-mentioned IEEE standard. The low-speed path is used to transmit control signals, such as channel selection and data packet acknowledgment signals, back to a low-speed transmitter/receiver 58, or to a low-speed receiver only, in access point 22.

Remote controls 30, 40 and 42 communicate with access point 22 and with displays 24 and 26, respectively, over low-speed paths 46. For example, as shown in Fig. 2B, remote control 40 comprises a low-speed transmitter/receiver 60, which communicates with transmitter/receiver 54 of display 24. Some remote control commands sent over path 46 from remote control 40 to display 24 are processed locally by the display, while others, such as channel selections, are relayed back over path 46 to transmitter/receiver 58 of access point 22 for processing. Alternatively, remote control 30 may be used to convey the commands directly to the access point. The remote controls preferably comprise devices such as personal digital assistants (PDAs), also known as "palmtop" computers, with a suitable RF communication interface, represented by transmitter/receiver 60. Alternatively, the remote controls may comprise dedicated remote control devices.

Although preferred embodiments described herein are based on the IEEE 802.11 standard and therefore operate at certain specified frequencies and data rates, it will be appreciated that other wireless frequencies, standards and data rates may be substituted in a straightforward manner. Similarly, communication over high-speed data

paths 44 may be at a higher or lower rate than that described above, depending on the choice of wireless LAN standard and the required data bandwidth. For example, communication over control paths 46 may be in accordance
5 with the emerging "blue tooth" standard, while communication over data paths 44 takes place in the 2.4 GHz band, with data rates up to 11 Mbps, as specified by the above-mentioned 802.11 standard. Preferably, access point 22 adjusts its bandwidth and allocation of radio
10 resources adaptively, in response to the demands and capacity of the peripheral devices requesting transmission of video or other data.

Fig. 3 is a diagram that schematically illustrates data and message flow in network 20, in accordance with a preferred embodiment of the present invention. The bold
15 arrows in the figure illustrate high-speed data transmission over paths 44, while the fine arrows illustrate low-speed control and network management traffic over paths 46. The figure illustrates how access point 22 serves displays 24 and 26 concurrently.
20

At a time corresponding to the top of the diagram, the access point is transmitting video packets to display 26 over path 44 and receiving an acknowledgment of each packet on path 46. A user actuates remote control 40 in
25 order to request video service on display 24. The message from the remote control is conveyed on path 46 via transmitter/receiver 54 of the display to access point 22. The access point responds by beginning to send the requested video packets to display 24. Upon receipt
30 of the first packet, the display both sends an acknowledgment back to the access point and passes an acknowledgment of video reception to remote control 40. Thereafter access point 22 continues to exchange video packets with both display 24 and display 26. Preferably,

the communications between the access point and the two displays are staggered, as shown in the figure, so that the two displays are served in alternation.

Fig. 4 is a block diagram that schematically illustrates communications carried out among elements of network 20, in accordance with another preferred embodiment of the present invention. This embodiment can coexist with the embodiment of Figs. 2A and 2B, i.e., network 20 can simultaneously support the communications illustrated in all of these figures. They are shown here as separate embodiments for the sake of visual clarity.

In the embodiment of Fig. 4, personal computer 32 comprises a high-speed RF transmitter, like transmitter 50 in access point 22 (Fig. 2B), which it uses to transmit video data over path 44 to be displayed by display 28. The computer also has a low-speed receiver, by means of which it receives control signals from the display over path 46. Preferably, one or both of computer 32 and access point 22 also comprise high-speed receivers, such as an optional 5.5 GHz receiver 56, shown in Fig. 2B. Such receivers enable the access point and computer to exchange high-speed data, such as video or interactive multimedia screens that are downloaded over the high-speed public network to which access point 22 is connected.

While the figures described herein show certain configurations and communication paths among the elements in network 20, other possible configurations and paths will be apparent to those skilled in the art. Furthermore, although preferred embodiments are described hereinabove with reference to home networking, and particularly to distribution of video data over home networks, it will be understood that the principles of the present invention may similarly be applied to

transmission of other types of high-speed data, whether in the home or in facilities of other types. It will thus be appreciated that the preferred embodiments described above are cited by way of example, and that the
5 present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and
10 modifications thereof which would occur to persons skilled in the art upon reading the foregoing description and which are not disclosed in the prior art.

CLAIMS

1. A data distribution device, comprising:
 - a high-speed radio-frequency (RF) wireless transmitter, operative to transmit digital data to one or more peripheral devices at a high data rate over a wireless local area network in a broad band at a first frequency; and
 - a low-speed RF wireless receiver, operative to receive signals returned by the one or more peripheral devices over the network in a narrow band at a second frequency.
2. A device according to claim 1, wherein the digital data comprise video data, and wherein the one or more peripheral devices comprise one or more displays, which receive the transmitted video data and display video images responsive thereto.
3. A device according to claim 2, wherein the one or more displays comprise a plurality of displays, and wherein the transmitter is adapted to transmit a different respective channel of the video data to each of the displays.
4. A device according to claim 3, wherein the signals returned by the one or more peripheral devices indicate a choice of the respective channel made by a user of one of the displays.
5. A device according to any of claims 1-4, wherein the device is coupled to receive the digital data at the high data rate from a public communications network.
6. A device according to any of claims 1-4, wherein the first frequency is between 5 and 6 GHz, and the second frequency is between 2 and 3 GHz.

7. A device according to claim 6, wherein the transmitter and receiver are respectively operative to transmit the data and to receive the signals substantially in accordance with IEEE standard 802.11.
- 5 8. A device according to any of claims 1-4, wherein the device comprises a personal computer.
9. Home networking apparatus, comprising:
an access point, operative to transmit digital data over the air at a high data rate in a broad band at a
10 first frequency; and
one or more peripheral devices, operative to receive the digital data transmitted by the access point and to return signals to the access point at a low data rate in a narrow band at a second frequency.
- 15 10. Apparatus according to claim 9, wherein the digital data comprise video data, and wherein the one or more peripheral devices comprise one or more displays, which receive the transmitted video data and display video images responsive thereto.
- 20 11. Apparatus according to claim 10, wherein the one or more displays comprise a plurality of displays, and wherein the access point is adapted to transmit a different respective channel of the video data to each of the displays.
- 25 12. Apparatus according to claim 11, wherein the signals returned by the one or more peripheral devices indicate a choice of the respective channel made by a user of one of the displays.
- 30 13. Apparatus according to any of claims 9-12, wherein the access point is further coupled to communicate over a public communications network so as to receive the

digital data therefrom for transmission to the peripheral devices.

14. Apparatus according to any of claims 9-12, wherein the first frequency is between 5 and 6 GHz, and the
5 second frequency is between 2 and 3 GHz.

15. Apparatus according to claim 14, wherein the access point and the peripheral devices are respectively operative to transmit the data and the signals substantially in accordance with IEEE standard 802.11.

10 16. Apparatus according to any of claims 9-12, and comprising a personal computer, coupled to communicate over the air with the access point in the broad band.

17. Apparatus according to any of claims 9-12, and comprising a remote control device, adapted to
15 communicate over the air in the narrow band with at least one of the access point and the peripheral devices.

18. Apparatus according to claim 17, wherein the remote control device is operative to communicate over the air with one of the peripheral devices, which is further
20 operative to return the signals to the access point responsive to communication with the remote control device.

19. A method for data distribution, comprising:
transmitting digital data over the air to one or
25 more peripheral devices at a high data rate over a wireless local area network in a broad band at a first frequency; and

receiving signals returned by the one or more peripheral devices over the network in a narrow band at a
30 second frequency.

20. A method according to claim 19, wherein transmitting the digital data comprises transmitting video data to one

or more displays, which receive the transmitted video data and display video images responsive thereto.

21. A method according to claim 20, wherein transmitting the video data comprises transmitting a different
5 respective channel of the video data to each of the displays.

22. A method according to claim 21, wherein receiving the signals comprises receiving a choice of the respective channel made by a user of one of the displays.

10 23. A method according to claim 19, wherein transmitting the digital data comprises receiving the digital data to be transmitted from a public communications network.

24. A method according to claim 19, wherein the first frequency is between 5 and 6 GHz, and the second
15 frequency is between 2 and 3 GHz.

25. A method according to claim 24, wherein transmitting the data and receiving the signals respectively comprise transmitting the data and receiving the signals substantially in accordance with IEEE standard 802.11.

20 26. A method according to any of claims 19-25, wherein transmitting the digital data comprises transmitting data to a personal computer.

27. A method according to any of claims 19-25, and comprising receiving signals in the narrow band at the
25 second frequency from a remote control device.

28. A method according to any of claims 19-25, and comprising receiving digital data in the broad band at the first frequency from a personal computer.

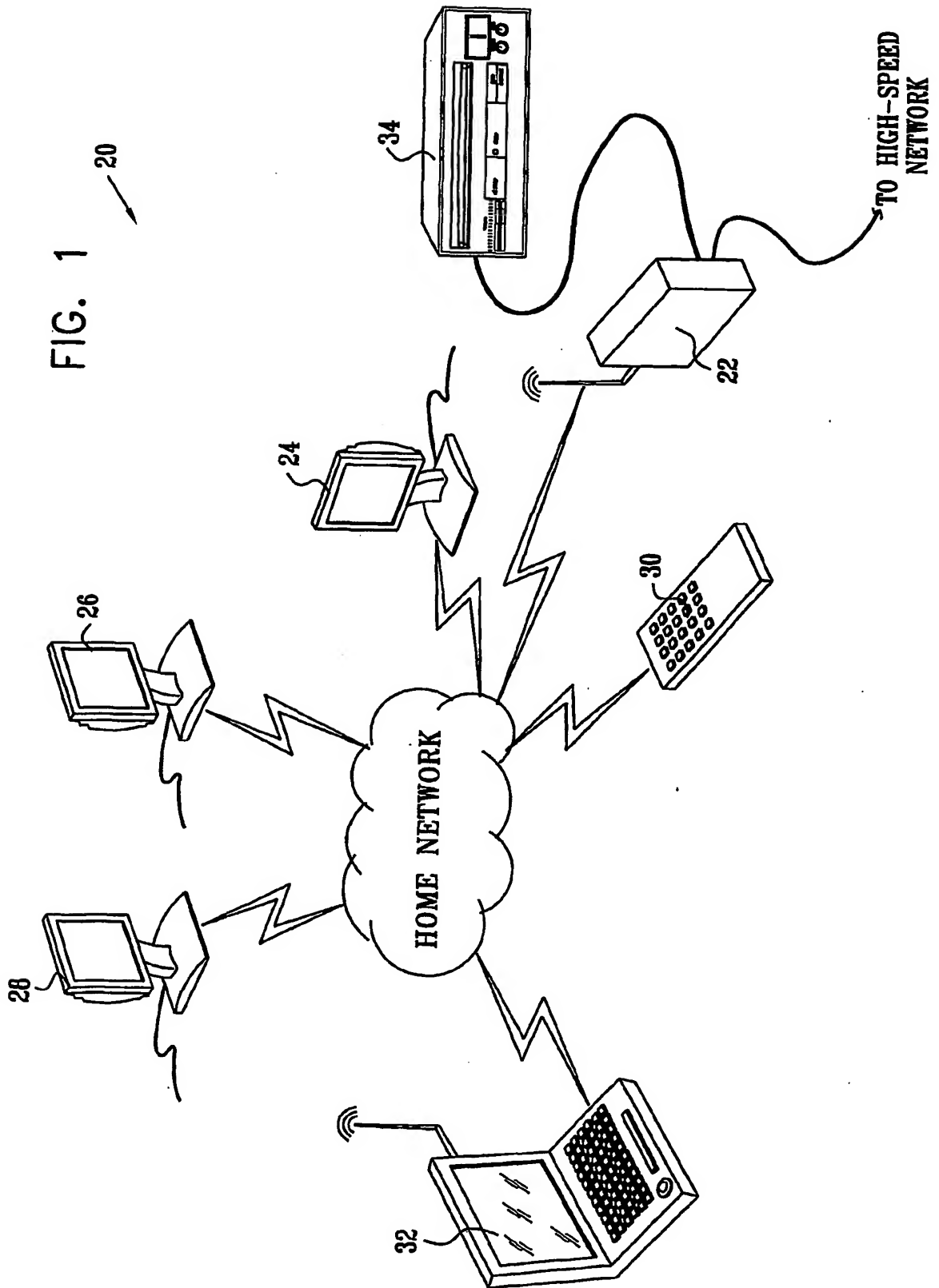
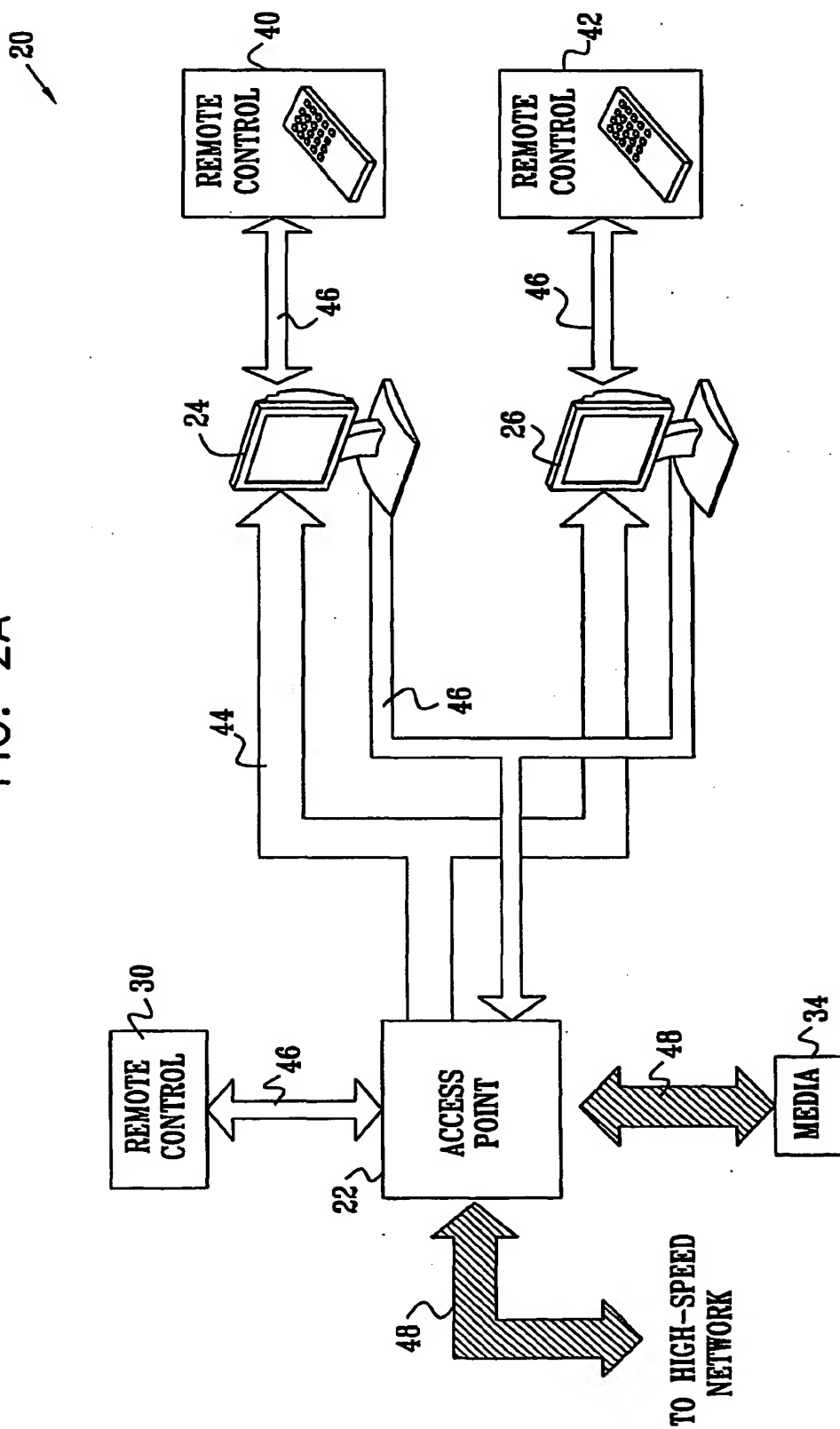


FIG. 2A



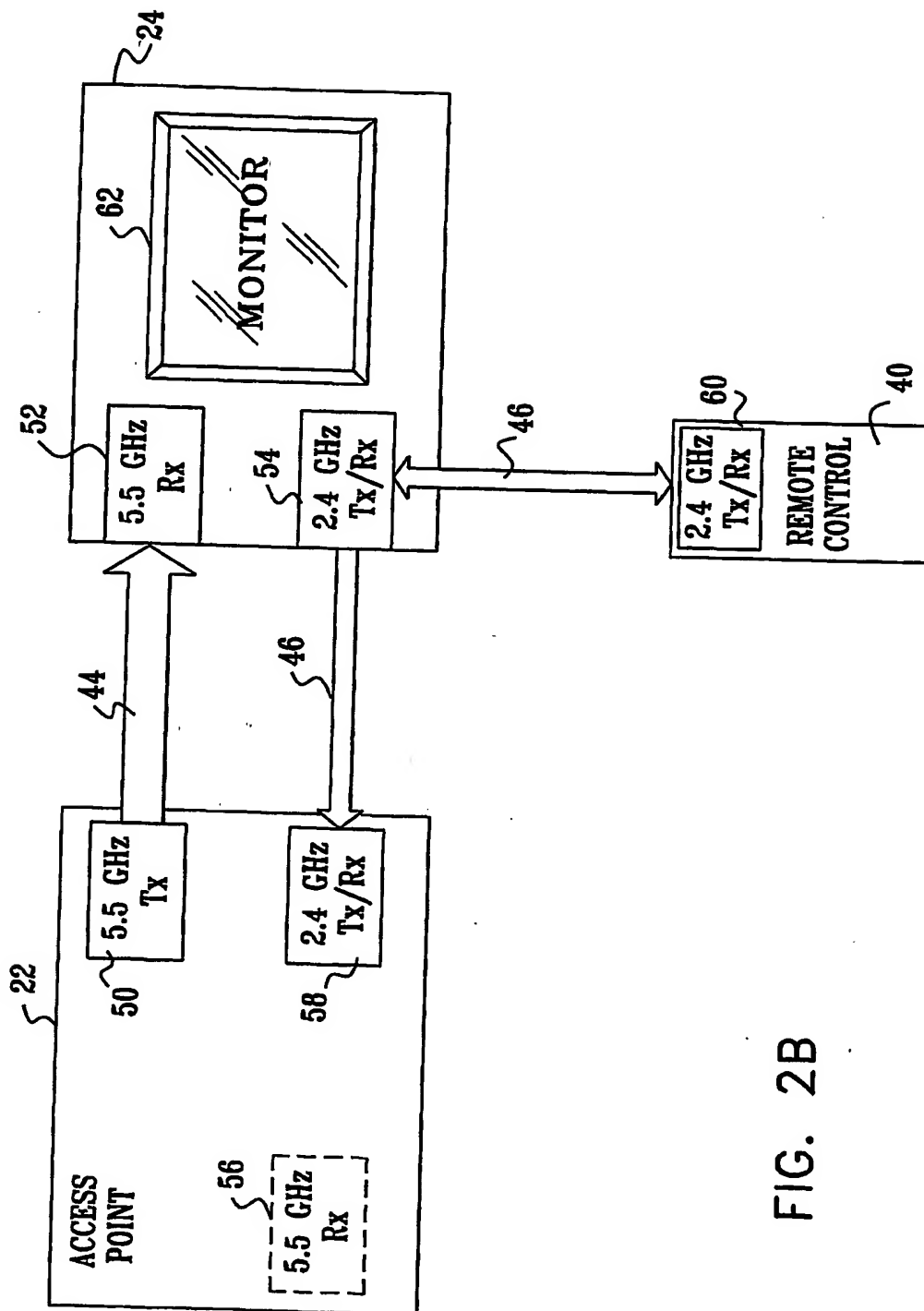


FIG. 2B

FIG. 3

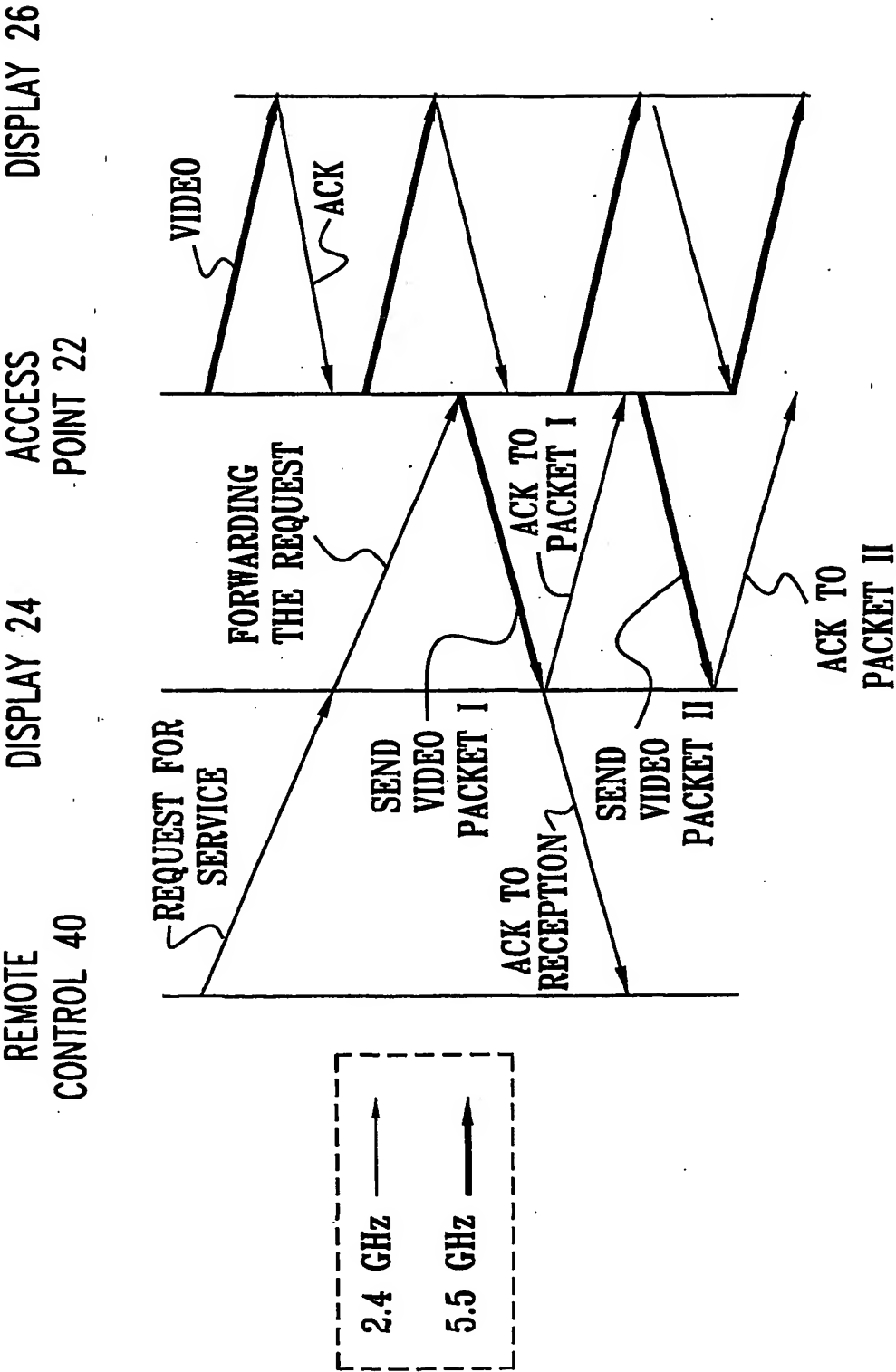


FIG. 4

